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ABSTRACT

This study investigated the following questions: (1) "What are the perceptions that elementary school principals have concerning the influence of interior design elements such as floor and wall coverings, lighting, flexibility, acoustics, color, texture, patterns, cleanliness, and maintenance on student achievement, teacher retention, and student attendance?" (2) "Do the acoustics of the environment relate significantly to student achievement?" (3) What floor coverings in the classroom relate significantly to the acoustics of the classroom?" and (4) "Are there any possible links between floor coverings in the classroom and student achievement?" The study found that in all subject areas studied, students attending schools having carpeted classrooms had higher achievement scores than those attending schools with hard surfaced classrooms. It also found that the importance of interior design of a school is a slightly higher priority for school principals than teachers. (Contains 66 references.) (EV)

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ED 478 177

The Importance of Interior Design Elements as They Relate to Student Outcomes

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Abstract

Although there is some documented information about perceptions of teachers concerning the physical environment and its influence on student learning, behavior, and achievement, the literature is silent regarding perceptions of elementary school principals on importance of interior design elements, including floor coverings, in schools and the influence of floor covering on student achievement. The issues of the floor covering's role in absorbing noise, its contribution to classroom flexibility, safety, and security were investigated with respect to student achievement. The issues addressed in this study were investigated according to these questions:

1. What are the perceptions that elementary school principals have concerning the influence of the interior design elements such as floor and wall coverings, lighting, flexibility, acoustics, color, texture, patterns, cleanliness, and maintenance on student achievement, teacher retention, and student attendance?

2. Does the acoustics of the environment relate significantly to student achievement?

3. What floor coverings in the classroom relate significantly to the acoustics of classroom?

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EF 006 318

4. Are there any possible links between floor coverings in the classroom and student achievement?

The population for this study included public elementary schools in Georgia in the year 2002. To collect perceptual data, a questionnaire was distributed to a random sample of 100 public elementary school principals in Georgia. Based on the results of this survey, a sample of schools having carpeted and hard surface flooring in classrooms were selected for site visits to measure reverberation time and background noise. A sound level meter and reverberation meter were used for measuring acoustics. Information regarding student performance, teacher experience, and certification was also gathered from official records. Over 93% of the principals noted that the general classroom design has a somewhat strong impact on student achievement. When student achievement was analyzed, the control variables included socioeconomic status and teacher education and experience, while the volume of the classroom, surface area, and background noise were used in comparing reverberation times. A negative correlation was found when reverberation times and student mathematics achievement were analyzed, indicating that student mathematics achievement scores in classrooms with lower reverberation times were higher. In all subject areas studied, students attending schools having carpeted classrooms had higher achievement scores than those attending schools in hard surfaced classrooms.

Overview of the Study

Introduction

School construction is becoming a major industry in the United States. Counties, cities, districts, and states are allotting fiscal funds and taxpayer dollars to build the newest, most modern and technologically advanced facilities in which to educate people for the future. As educators embrace how to adequately prepare students for their academic futures, there arises the question of where to educate these individuals, and these concerns are not necessarily limited to a certain state, town, or city. The dilemma focuses on specifically in what type of facility are students given the best advantage in which to most greatly benefit their learning. As this particular issue surfaces, many of the school buildings presently inhabited by students and staff are viewed to be in declining conditions. Local school boards throughout the country continually struggle with the decision to renovate, add to, or construct new facilities to meet the growing population needs (Castaldi, 1994). Such a decision is difficult to make when trying to consider short and long-term expenses and production and correlate this information with demanding requirements and community desires (Tanner, 2000b).

Any commitment made by a local school board requires community support in order to adequately meet the needs of parents, students, and area businesses. The undertaking by a school board to make a decision relating to facility construction is a lengthy and ongoing process which usually begins with a comprehensive school study involving a community and economic analysis, education program analysis, financial analysis, and building reviews (Castaldi, 1994; NCES, 2000). The school facility is a large infrastructure with many technical specifications that must be examined thoroughly in order to create the most appropriate spaces for student learning and teaching. The

perceptions that teachers and principals have about where students learn should now be considered as a guide to conducting research on the physical environment's influence on student achievement and behavior. This particular study focused on perceived variables that may link student achievement and the physical environment, specifically the various floor coverings as they influence the acoustics of the environment.

Statement of the Problem

Although there is some documented information about the perceptions of teachers concerning the physical environment and its influence on student learning, behavior, and achievement (Schapiro, 2000), the literature is silent regarding the perceptions of elementary school principals on the importance of interior design elements, including floor coverings, in schools. For example, there is a lack of information regarding what elementary school principals perceive about the impact of interior design elements such as acoustics, maintenance, cleanliness of the school, color and color patterns, textures of the floors and walls, the floor covering's role in absorbing noise, classroom flexibility, safety, and security relating to student achievement. Beyond perceptions of teachers and principals, there exist only a few scientific studies of the influence of the physical environment on student achievement (Heschong Mahone Group, 1999; Tanner, 2000b; Weinstein, 1979; Yarborough, 2001). While The National Center for Educational Statistics (2000) provided some research in the area of school facilities concerning age and maintenance of buildings, it failed to include data relating the physical environment to student learning.

In order to address this dearth in the literature, this study addressed principals' perceptions of the physical environment. Using the results of the principals' perceptions, a sample of schools having both a "perceived good and bad acoustical environment" was selected for further study. The latter component of the study dealt with acoustical measures in the "perceived good and bad acoustical environments" and compared the measures of sound levels in these two environments to student achievement. The issues of the floor covering's role in noise absorption, its contribution to classroom flexibility, safety and security were investigated with respect to student achievement.

Purpose

One purpose of this study was to extend the findings of Schapiro's 2000 study to include the perceptions of elementary school principals regarding the interior design of the schools. Schapiro (2000) discovered that 73% of a national sample of teachers perceived the interior design of schools to be very important for creating a good learning environment; 55% perceived that classroom design impacts student achievement; and 69% of the teachers preferred carpet or a combination of carpet and linoleum, tile, or hardwood. Another purpose of this study was to provide an objective measurement of student achievement and determine if it is possibly a function the acoustical environment. The underlying theory relevant to this research was that the space where the children learn makes a significant impact upon academic achievement. More specifically, this study was designed to explore the effects of the type of flooring in the classroom on student outcomes.

Importance of the Study

No studies have yet dealt collectively with the perceptions of the school leader, the principal, regarding the impact of interior design components such as acoustics, comfort and safety, and aesthetic effects of floor coverings upon the student's academic

achievement. Why is it important to know the perceptions of the school leader? As Hart and Bredeson (1996) have pointed out, "Principals are central players in bringing about improvement in educational outcomes for all learners in their schools" (p. 33). The principal is the instructional leader of a school and has the immediate responsibility for the school facility. Furthermore, school systems should involve the school principal in the planning and design of the school (McGhee, 2001). From the results of this study, school administrators and architects can use the information provided to create future optimal learning environments or modify existing ones using allotted funds for the most appropriate type of floor covering that will foster student academic growth. In essence, the findings from this study may fill the void that exists in what is now offered as information for the construction of the school facility.

Research Questions

Given the gaps in the research as delineated in the previous sections, the following research questions guided the two parts of this study:

1. What are the perceptions that elementary school principals have concerning the influence of the interior design elements such as floor and wall coverings, lighting, flexibility, acoustics, color, texture, patterns, cleanliness, and maintenance on student achievement, teacher retention, and student attendance?
2. Does the acoustics of the environment relate significantly to student achievement?
3. What floor coverings relate significantly to the acoustics of classroom?
4. Are there any possible links between floor coverings in the classroom and student achievement?

Assumptions

Several assumptions guided this study. First, it was assumed that appropriate methodology and instrumentation could be designed to scientifically answer the research questions. Second, socioeconomic and other variables were controlled in order to create an unbiased sample and make comparisons regarding student achievement among the schools. Third, it was assumed that the existing measures of student achievement were unbiased, valid, and reliable. Finally, it was assumed that the measures of the acoustical environment and the questionnaire were valid and reliable (See Table 3.1).

Summary of Procedures

For the purpose of this study, sets of data were gathered to answer the research questions. One set of data was related to the physical environment; another set dealt with the population of students and teachers. The population included the public elementary schools of Georgia in 2002. The sample (classified as rural, urban, and rural-urban) consisted of 100 randomly selected schools having pk-5 or k-5 organizational structure.

To collect the perceptual data, a questionnaire was created and sent to a random sample of 100 public elementary schools in Georgia. The questionnaire was validated in Spring 2002. This questionnaire, completed by the principals of the schools, was similar to that used in the national survey of school teachers by Schapiro (2000). The survey question regarding the present type of floor covering in classrooms was used to select schools to be visited. Other variables of particular importance to this study addressed by the questionnaire included acoustics, comfort and safety, and aesthetics. Thirty-one of these schools were selected for site visits. Schools were divided into two categories: those with "perceived good and bad acoustics".

Other instruments were needed to measure acoustics in the sample of schools. A digital sound level meter (Model 407764) was used to measure initial background decibels, and a reverberation time meter (Goldline – GL 60) was used in measuring reverberation time. The researcher, to learn the appropriate use of this instrument and ensure a systematic data set for the 31 schools, attended a special seminar determining the most effective procedures to collect acoustical data in an existing school building. Measures of acoustics in the 31 schools were taken scientifically with the standardized instruments and measurement procedures.

Following the collection of the environmental data, information regarding student performance and teacher experience and certification was gathered for each of the schools. These data were collected from recent standardized testing scores and information indicating student ethnicity and socioeconomic status were also collected. Data regarding teachers that were collected included teacher training, experience, and certification level. These factors relative to the teaching staff and socioeconomic status were used as covariates to ensure valid comparisons on the dependent variable of student achievement. Furthermore, information regarding school characteristics and floor covering was also detailed in the analysis. Following data coding, statistical treatment included frequency counts, percentages, analysis of variance, and multiple regression analysis (alpha $\leq .05$).

Limitations of the Study

Some limitations, constraints, considerations, and gaps that may have hindered accurate findings were inherent in this study. Assessment of acoustics was thorough, given the instrumentation. The instruments used for sound measure were the Extech Sound Meter and the Goldline reverberation time meter (GL 60). Many other variables possibly caused limitations. For example, the evaluation was dependent on the responses to the mail out survey. Socioeconomic status was represented in all schools studied through percentages of free and reduced lunches serving as indicators. Teacher quality was another concern for the sample studied, given as the education level of the teachers, teachers having the same degree of education from various institutions of higher education may not provide equal services to students through teaching. Even equal levels of certification may be questioned regarding quality of teaching. These gaps in the study were addressed and acknowledged as limitations associated with the conclusions and findings.

Presentation and Analysis of Data

A mail out questionnaire was sent to 100 randomly selected elementary principals in Georgia. In order to qualify for the study, the elementary school was required to include kindergarten through the fifth grade or pre-kindergarten through the fifth grade. Of the surveys mailed, 48 were returned, and 45 were usable as some were not adequately completed. Using the responses from the survey, specifically the question regarding floor covering and acoustical environment, there were 31 schools selected for site visits. However, some principals responded to the question with the whole school in mind, rather than the classrooms. This was discovered during site visits and justified the data reduction as noted later in this chapter. Additionally, the condition of the floor covering and the acoustical rating of the classroom were factors determining whether or

not a school would be included for a site visit. This variable also figured into the necessary data reductions.

Supplemental data noting fifth grade test scores were collected for those schools identified for school visits. Specifically, test score information from the 2001 Stanford-9 was obtained via the School Report Card posted on the Internet by the Georgia Department of Education. Along with the test scores, other information including school size, student ethnicity, the reduced and free lunch ratio, teacher certification, and teacher experience were also reported. The reduced and free lunch information was used to approximate socioeconomic status (SES). The variables used as covariates in the analysis of the student data were SES of the students, teacher certification, amount of teacher training, and teacher experience. These were included to minimize bias in the findings.

During the site visits, an individual fifth grade classroom was examined noting the dimensions specific to surface area and volume. Other notations on a checklist were made specifying HVAC operation status, ceiling material, wall material, absorbing materials, furniture arrangement, floor covering type, color, and quality. These variables were included to assist in decisions about data reduction, if that became necessary. They were also needed to clarify any unusual variability in background noise and reverberation times.

In order to determine initial background noise, the decibel reading meter was placed in the center of the room, and the settings were placed on slow and 30 rather than fast or any other logging level. These speeds were the recommended settings by the manufacturer. This omni-directional recording instrument measured the background noise of the classroom. The reverberation time of the classroom was identified through the use of the reverberation time meter. This instrument was placed in the same position as the decibel reading meter. The researcher stood at the center of the largest white board area to produce the sounds to be measured for reverberation time. This was always in the front of the classroom and was assumed to be the place where the teacher did the majority of instruction. The reverberation time meter was set on the standard settings recommended by the individual manufacturers for the instrument. A paper bag was blown to capacity and popped to create the first noise to be recorded. Bags of equal sizes were used through the testing. The reverberation time meter was reset to original settings, and the starter pistol was fired and the reverberation time was recorded. All of the information and data collected were documented in a database relative to each school code. These procedures and methods of data collection were used to provide information for assessing the following ***research questions:***

Perceptions of Elementary School Principals - Question 1

Because of identified gaps in the literature, this study focused on this question: What are the perceptions that elementary school principals have concerning the influence of the interior design elements such as floor and wall coverings, lighting, flexibility, acoustics, color, texture, patterns, cleanliness, and maintenance on student achievement, teacher retention, and student attendance? Using the survey results, frequency counts were completed.

Table 1 Responses to Questions # 1 - 3

Question	2- Not very important	3- Somewhat important	4- Very important
1-Importance of			

school's interior design for creating a good learning environment	2.1%	2.1%	95.8%
2-Importance of school's interior design for teacher retention	8.3%	54.2%	37.5%
3-Importance of school's interior design for student attendance	12.5%	60.4%	25%

Table 1 and Figure 1 identify the principals' perceptions of questions #1 –3 of the survey. Approximately 98% of the responders noted that the school's interior design is important for creating a good learning environment.

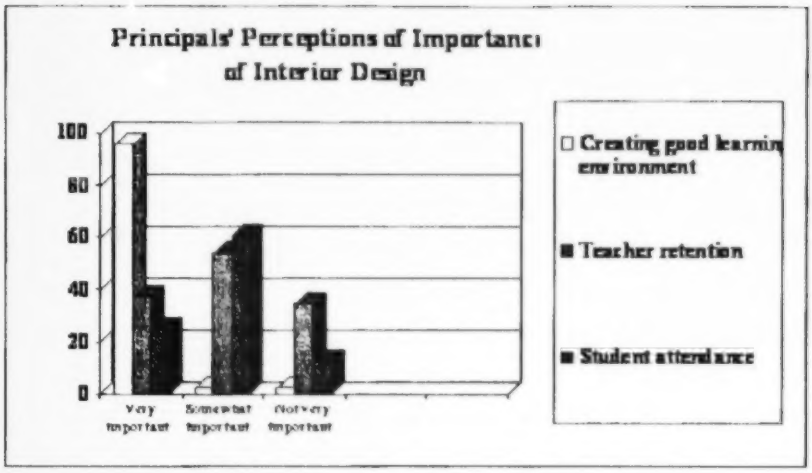

Figure 1 Importance of Interior Design

Questions #4- 17 asked principals to indicate the impact particular design aspects of the classroom have upon student achievement. Of those responses, 93.7% of the principals suggested that the general classroom design had a somewhat to strong impact on student achievement. More specifically, 4% indicated the classroom design has very little impact; while, 59% noted the classroom design has a somewhat strong impact, and 35% agreed that the classroom design has a very strong impact on student achievement.

Figure 2 outlines the principals' perceptions of the overall impact of the classroom design upon student achievement (question 4). Student achievement is impacted strongly by the classroom's physical environment, according to 94% of the principals surveyed.

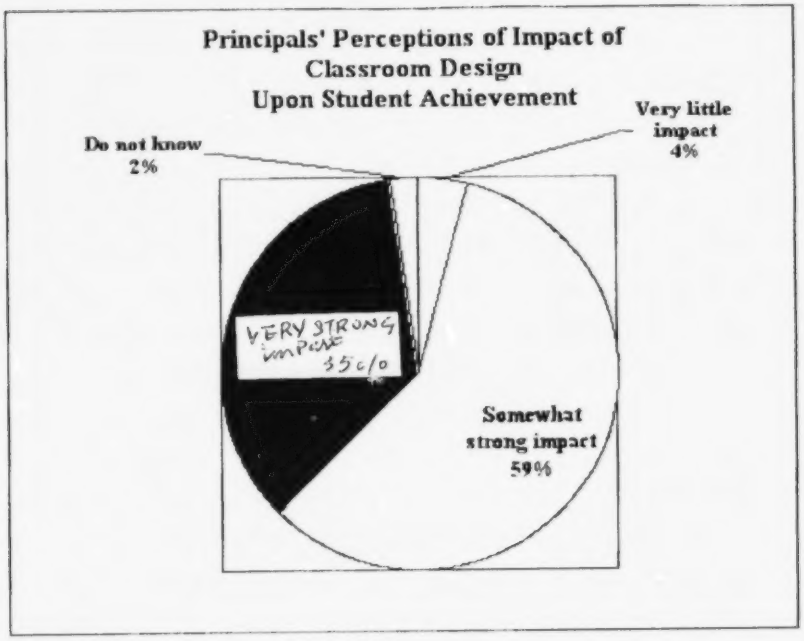

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Figure 2 Impact of Classroom Design

Questions #5-7 of the survey dealt with the perceptions of elementary school principals regarding the lighting of classroom and the flexibility to arrange the classroom and the impact these factors have upon student achievement. For example, Table 2 identifies that natural lighting is perceived to have a strong or very strong impact on student achievement by 85.4 % of the principals.

Table 2 Responses to Questions #5 - 7

Question	1-No impact at all	2- Very little impact	3- Somewhat strong impact	4- Very strong impact	5- Do not know
5-Impact natural lighting in classroom has on student achievement	0%	6.3%	20.8%	64.6%	8.3%
6-Impact the ability to control lighting in classroom has on student achievement	2.1%	4.2%	43.8%	50.0%	0%
7-Impact flexibility to arrange classroom has on student achievement	0%	10.4	31.3%	58.3%	0%

Question #8 of the survey introduced the floor covering topics specifically regarding the impact a carpeted classroom has on student achievement. Fifty percent of the principals suggested that carpet has somewhat strong impact to very strong impact on student achievement. Of this 50%, 12.5% viewed the impact to be a very strong one upon student achievement. Only 4.2% noted that carpet has no impact at all on the student achievement, and 37.5% reported the carpet has very little impact on student achievement.

Table 3 notes the assessment of questions #9 – 12 which focused on the impact of quiet environment in the classroom, minimizing accidents in the classroom, ease of cleaning the classroom, and comfortable seating on student achievement. These questions focused on the impact that safety, security, and comfort might have on student achievement. For example, 97.9% indicated that acoustics had a somewhat to very strong impact on student achievement.

Table 3 Responses to Questions #9 – 12

Question	2- Very little impact	3- Somewhat strong impact	4- Very strong impact
9-Impact a quiet environment with good acoustics has on student	2.1%	27.1%	70.8%

achievement			
10-Impact classroom that minimizes risk of accidents on student achievement	4.2%	29.2%	66.7%
11-Impact a classroom that has comfortable seating for students has on student achievement	18.8%	43.8%	37.5%
12-Impact of comfortable seating for students has on student achievement	0%	31.3%	68.8%

The next three questions of the survey centered on the aesthetics of the floor covering. Approximately 63% reported that attractive floor colors have a somewhat strong to very strong impact upon student achievement. Over half of those surveyed, 56.3%, indicated the texture of the floor had little to no impact on student achievement, and 16.5% were unsure of the impact of the floor texture. Fifty percent noted the patterns of the floor covering had little to no impact upon student achievement.

Questions #16 and #17 examined principals' perceptions and the maintenance of and ease of cleaning the floor covering in their schools. Eighty-three percent responded that the floor covering of their school was well to very well maintained. Eighty-five percent of the responses indicated their floor coverings were well to very well cleaned.

Table 4 provides information regarding principal perceptions with specific focus on carpet. Issues of safety, acoustics, maintenance, and comfort are addressed. For example, 66.7% of the responders agreed that carpet helps prevent injuries in the classroom.

Table 4 Responses to Questions #18 – 22

Question	Strong Disagree	Somewhat Disagree	Somewhat Strongly Agree	Very Strongly Agree	Do Not Know
18-Carpet absorbs noise helping to make a classroom quieter	0%	4.2%	33.3%%	60.4%	0%
19-Carpet helps to prevent falls and injuries making a classroom safer	4.2%	18.8%	39.6%	27.1%	8.3%
20-Carpet gives a teacher more flexibility, such as allowing children to sit comfortably on	2.1%	6.3%	39.6%	47.9%	2.1%

the floor					
21-Carpet is easy to maintain	20.8%	31.3%	35.4%	6.3%	4.2%
22-Comfortable to stand teaching	0%	6.3 %	27.1%	62.5%	2.1%

Figure 3 outlines principals' perceptions concerning carpet maintenance noting that 42.6% agreed that carpet is somewhat easy to maintain, while 21.3% strongly disagreed.

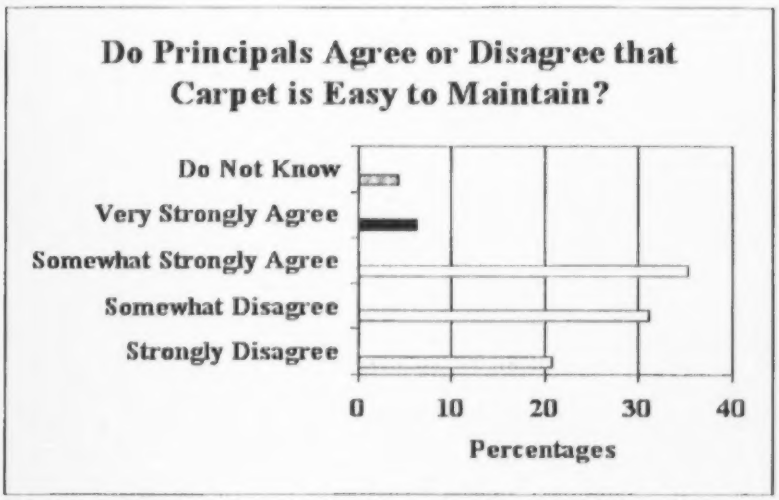

Figure 3 Ease of Carpet Maintenance (Question 21)

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Questions #23-24 focused on the condition of the principals' schools and classrooms. Figure 4 outlines principals' perceptions concerning overall conditions of schools. Nineteen percent reported their schools to be in poor to fair condition, and 81% indicated the condition of their schools as good, very good, or superior.

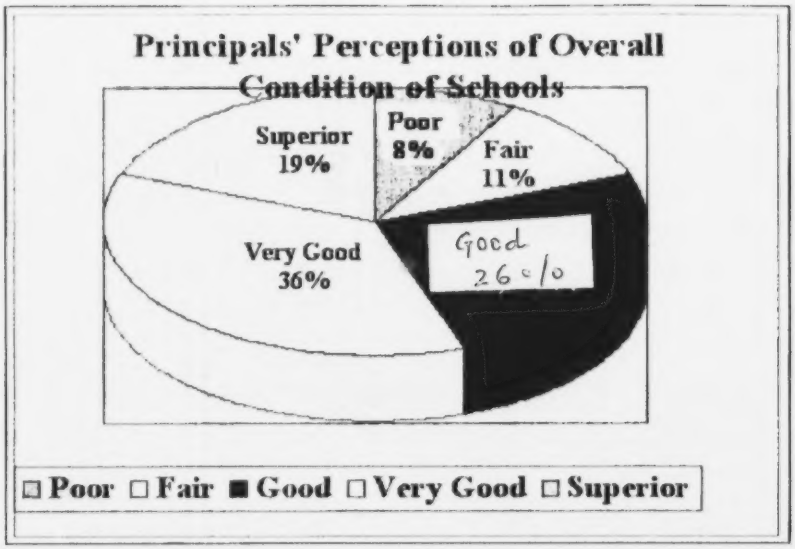

Figure 4 Principals' Perceptions Relevant to Overall School Conditions

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The classrooms received a similar percentage rating. Nineteen percent of the principals noted that the classrooms were in poor to fair condition. Eighty-one percent indicated that the classrooms were in good to superior condition. Only 26% rated the classrooms to be in good condition.

Fifty-one percent of those responding indicated the classrooms in the school were covered with carpet and 10.6% of the principals noted that their classrooms had tile floor covering. Another 8.5% identified hard surface coverings other than tile and 29.8% were classified as "combination". The floor covering colors of either light or neutral were reported by 75.6 % of the principals, while 20% and 4.4% were dark and very dark, respectively. The mean age range of the school was 21 to 30 years old; while the average number of years in education of the principal ranged from 16 to 20 years.

The responders noted that 51.1% of their schools' classrooms were carpeted, while 29.8 percent had a combination of hard surfaces and carpet. The other classrooms were covered with hard surfaces such as hardwood, vinyl, or tile (19.1 %). Almost 16% preferred hard floor surfaces, while over 84% preferred carpet and a combination of other surfaces (See Figure 5).

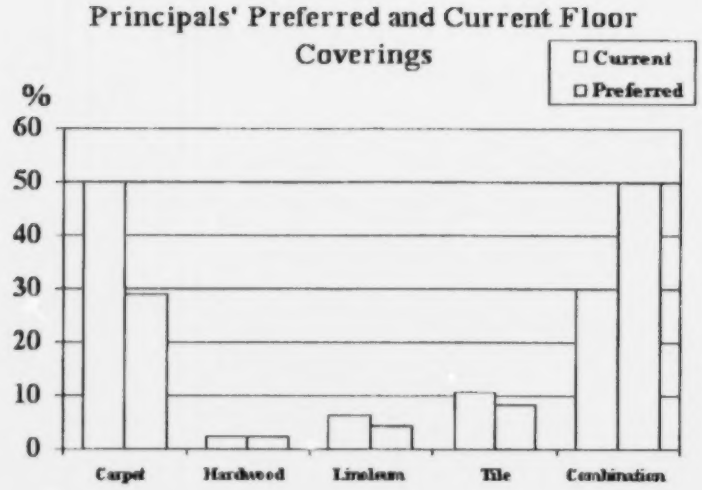

Figure 5 Principals' Preferred and Current Floor Coverings

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Table 5 and Figure 6 report the grades principals gave to the overall design of the classroom and acoustics of the classroom environment in their schools. Over 57% of the principals noted that there schools grade on Acoustics was below a "B", and 34.8% perceived the overall design of the classroom to be below the grade of "B".

Table 5 Acoustic and Design Grades

Area	A	B	C	D	F
Acoustics of Classroom	10.6%	31.9%	46.8%	6.4%	4.3%
Overall Design of Classroom	17.4%	47.8%	26.1%	8.7%	0%

Figure 6 further details principals' perceptions regarding acoustics' grades. Over 57% of the principals indicated that their schools' classrooms were below a "B". In fact, 10.7% of the schools received a grade below "C".

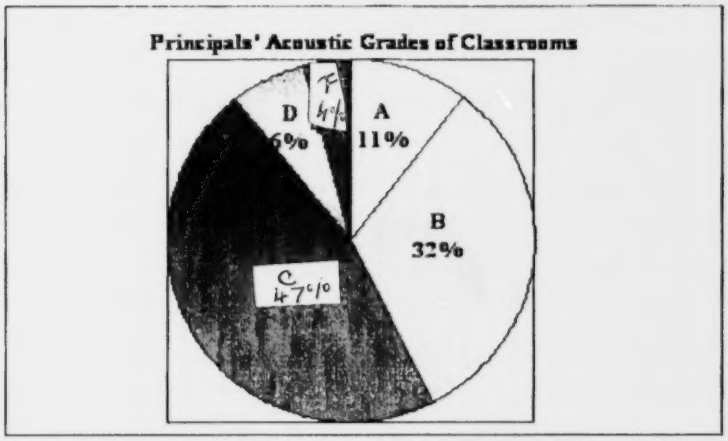

Figure 6 Acoustics' Grades

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Figure 7 demonstrates the perceptions of principals regarding overall design. Forty-eight percent gave the overall design a "B". Only 17% gave the overall design an "A", and 9% gave the design an "F". Twenty- six percent reported the grade of "C".

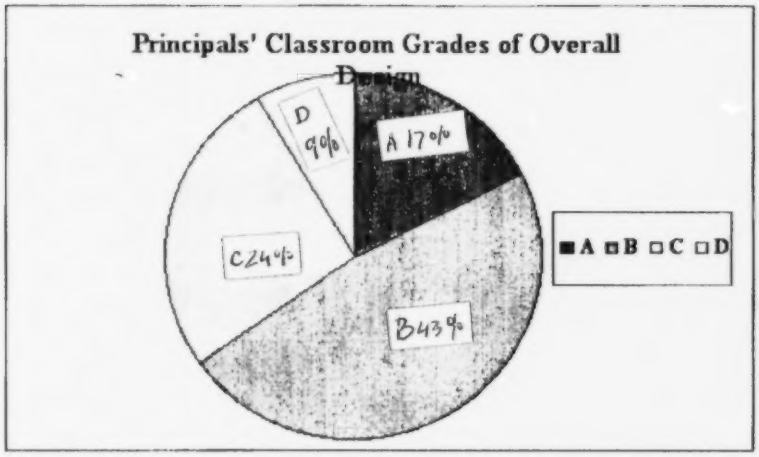

Figure 7 Classroom Grades

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Acoustics and Student Achievement - Question 2

In order to answer the second research question, a total of 31 schools were visited during the summer of 2002 to check classroom acoustics and assess the physical condition of classroom floor coverings. Since only 11 schools in the sample had no carpet (a fact not discovered in the returned questionnaires), the sample was first reduced to 11 schools having carpet and 11 schools without carpet. This reduction was accomplished by randomly eliminating 9 schools having carpet. This data set was further reduced to 10 schools in each category because of differences in wall coverings and ceiling materials and number of windows. It was hypothesized that equal numbers of carpeted and non-carpeted schools would minimize biased data.

The research question addressed in this section is: Does the acoustics of the environment relate significantly to student achievement? Working with a sample of 20 classrooms (10 carpeted and 10 hard surfaced – hardwood, linoleum/vinyl, or tiled) located in 20 school districts in Georgia, a selected fifth grade classroom was tested for background noise and reverberation time. First, background noise was tested with the decibel meter. Next a paper bag was "popped" to measure reverberation time with the reverberation time meter. Finally, the starter pistol (recommended by the Rensselaer Polytechnic Institute) was fired and the reverberation time was measured and recorded.

Given the assumption that background noise and reverberation time influenced what student hear in classrooms, these data were correlated to determine the relationships between reverberation times in the two classroom classifications. Before correlations were determined, the reverberation times were adjusted for classroom volume, surface area, and background noise through multivariate analysis for each floor type classification (carpet and hard surfaces, respectively) as noted in Table 6. No statistically significant difference was found between the reverberation times $F = 2.389$, $p = .092$ and $F = .90$, $p = .488$ for the starter pistol and paper bag, respectively (Table 6). This may be attributed to the R Squared values, however mean reverberation times were always longer in non-carpeted classrooms, regardless of the noise level source (starter pistol vs. "popped" paper bag).

Table 6 Adjusted Reverberation Times by Floor Covering and Source of Noise Level (Homogeneous Variances)

A. Between-Subjects Factors

		N
Actual floor covering	Carpet	10
	Hard Surfaces	10

B. Descriptive Statistics – Reverberation Times

	Actual floor covering	Mean	Std. Deviation
Starter pistol reverb	Carpet	1.0900	.1312

Hard Surfaces	1.1740	.1440
Total	1.1320	.1408
Bag reverb time		
Carpet	1.0090	.1429
Hard Surfaces	1.1120	.1966
Total	1.0605	.1754

C. Tests of Between-Subjects Effects

Source	Dependent Variable	Sum of Squares	df	Mean Square	F	Sig.
Corrected Model						
starter pistol reverb	.147	4	3.667E-02	2.389	.097	
bag reverb time	.113	4	2.830E-02	.900	.488	
Intercept						
starter pistol reverb	6.971E-02	1	6.971E-02	4.542	.050	
bag reverb time	4.419E-02	1	4.419E-02	1.406	.254	
Volume of Room						
starter pistol reverb	4.649E-02	1	4.649E-02	3.029	.102	
bag reverb time	2.095E-02	1	2.095E-02	.666	.427	
Surface Area						
starter pistol reverb	3.420E-02	1	3.420E-02	2.228	.156	
bag reverb time	8.567E-03	1	8.567E-03	.273	.609	
Initial Background Noise						
starter pistol reverb	2.920E-02	1	2.920E-02	1.902	.188	
bag reverb time	3.218E-02	1	3.218E-02	1.024	.328	
Floor covering						
starter pistol reverb	3.032E-02	1	3.032E-02	1.976	.180	
bag reverb time	7.461E-02	1	7.461E-02	2.374	.144	
Error						
starter pistol reverb	.230	15	1.535E-02			
bag reverb time	.472	15	3.143E-02			

Total					
starter pistol reverb	26.005	20			
bag reverb time	23.078	20			
Corrected Total					
starter pistol reverb	.377	19			
bag reverb time	.585	19			

R Squared = .389 (Starter Pistol)
R Squared = .194 (Paper Bag)

The achievement test scores were adjusted for socioeconomic status of the student, level of education of the teachers, and average number of years of experience of the teachers. Table 7 reveals the descriptive statistics and effects relative to the adjusted scores.

Table 7 Mean Adjusted Scores for Student Achievement

A. Descriptive Statistics (N = 20)

	Mean	Std. Deviation
Total Reading	53.6500	9.4327
Total Math	50.5500	9.0698
Complete Battery	51.7000	7.5957

B. Tests of Between-Subjects Effects

Source	Dependent Variable	Sum of Squares	df	Mean Square	F	Sig.
Corrected Model						
	Total Reading	972.798	3	324.266	7.228	.003
	Total Math	912.973	3	304.324	7.491	.002
	Complete Battery	638.754	3	212.918	7.447	.002
Intercept						
	Total Reading	3087.071	1	3087.071	68.816	.000
	Total Math	3704.918	1	3704.918	91.201	.000
	Complete Battery	2958.926	1	2958.926	103.494	.000
Surface area						

Total Reading	873.334	1	873.334	19.468	.000
Total Math	772.133	1	772.133	19.007	.000
Complete Battery	555.929	1	555.929	19.445	.000
Initial Background Noise					
Total Reading	1.569	1	1.569	.035	.854
Total Math	67.023	1	67.023	1.650	.217
Complete Battery	6.039	1	6.039	.211	.652
Floor Covering					
Total Reading	37.328	1	37.328	.832	.375
Total Math	56.792	1	56.792	1.398	.254
Complete Battery	48.565	1	48.565	1.699	.211
Error					
Total Reading	717.752	16	44.859		
Total Math	649.977	16	40.624		
Complete Battery	457.446	16	28.590		
Total					
Total Reading	59257.000	20			
Total Math	52669.000	20			
Complete Battery	54554.000	20			
Corrected Total					
Total Reading	1690.550	19			
Total Math	1562.950	19			
Complete Battery	1096.200	19			

R Squared = .584 (Total Mathematics)
R Squared = .575 (Total Reading)
R Squared = .583 (Complete Battery)

Regarding the research question (Does the acoustics of the environment relate significantly to student achievement?), a Pearson correlation was completed by using the adjusted scores and reverberation times (Table 8). Variables included total reading score

(39), total mathematics score (40), complete test battery (41), the starter pistol reverberation time (49), and the bag reverberation time (50). Negative correlations were found for all reverberation times and student achievement scores (Table 8.B). A statistically significant correlation (-.446) was found between the "popped" paper bags' reverberation times and mean adjusted mathematics scores (p = .049). The statistical relationships between the reverberation times of the "popped" paper bag and reading and the complete test battery were -.33 (p = .151) and -.359 (p = .120), respectively.

Table 8 Correlations Between Reverberation Times and Student Achievement Scores

A. Descriptive Statistics – Reverberation Times and Test Scores (N=20)

	Mean	Std. Deviation
Predicted Value Starter Pistol	1.1320	8.787E-02
Predicted Value Bag Time	1.0605	7.718E-02
Predicted Value Reading	53.6500	7.1554
Predicted Value Math	50.5500	6.9319
Predicted Value Total Battery	51.7000	5.7982

B. Correlations Between Adjusted (Predicted) Variables

	Predicted Value Starter Pistol	Predicted Value Bag Pop	Predicted Value Reading	Predicted Value Math	Predicted Value Total Battery
Predicted Value Starter Pistol	1.000	.349	-.069	-.043	.060
p	.	.132	.772	.856	.802
Predicted Value Bag Pop	.349	1.000	-.333	**-.446**	-.359
p	.132	.	.151	**.049**	.120
N	20	20	20	20	20

Floor Covering and Acoustics - Question 3

Does the floor covering in the classroom relate significantly to the acoustics of classroom? To answer this question, carpeted and hard surfaced classrooms are compared in Table 9 with respect to reverberation times and types of floor coverings. Control variables included background noise, volume, and surface area of the classrooms. \ There was a statistically significant difference in mean reverberation times between the two classroom types with respect to floor covering. For example, considering the reverberation times of the starter pistol, F = 5.700 (p = .028)), the mean reverberation time in carpeted classrooms (1.0900) was significantly lower than reverberation times in the hard surfaced classrooms (1.1740). A similar finding was noted for the reverberation times of the "popped" paper bag, F = 15.875, (p = .001), revealing that the reverberation times in the carpeted classrooms were significantly lower than those in hard surfaced classrooms.

Table 9 Comparison Between Reverberation Times in Carpeted and Hard Surfaced Classrooms

A. Descriptives – Reverberation Times

		Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Min	Max
				Lower Bound	Upper Bound			
Predicted Value Starter Pistol								
Carpet	1.0900	7.986E-02	2.525E-02	1.0329	1.1471	.93	1.19	
Hard Floor	1.1740	7.747E-02	2.450E-02	1.1186	1.2294	1.05	1.33	
Total	1.1320	8.787E-02	1.965E-02	1.0909	1.1731	.93	1.33	
Predicted Value Bag Pop								
Carpet	1.0090	5.404E-02	1.709E-02	.9703	1.0477	.95	1.12	
Hard Floor	1.1120	6.133E-02	1.940E-02	1.0681	1.1559	1.02	1.19	

Total	1.0605	7.718E-02	1.726E-02	1.0244	1.0966	.95 1.19

B. ANOVA

Mean Square	F	Sum of Squares	df		F	Sig.
Predicted Value Starter Pistol						
Between Groups	3.528E-02	1	3.528E-02	5.700	.028	
Within Groups	.111	18	6.190E-03			
Total	.147	19				
Predicted Value Bag Pop						
Between Groups	5.304E-02	1	5.304E-02	15.875	.001	
Within Groups	6.014E-02	18	3.341E-03			
Total	.113	19				

Links Between Floor Coverings and Student Achievement - Question 4

In order to assess the final research question, a comparison of student achievement according to floor type was made for reading, mathematics, and the complete test battery. Table 10 reveals that in all cases, students in classroom s having carpet scored higher in reading, mathematics, and on the total test battery than students in rooms having hard surfaces as a floor covering. While there were no statistically significant differences (alpha = .05), a trend was found in favor of carpeted classrooms.

Table 10 Student Achievement and Floor Covering

A. Descriptives

	Floor Covering	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Min	Max
				Lower Bound	Upper Bound			
Predicted Value Reading								

Carpet	54.8428	7.9622	2.5179	49.1470	60.5387	40.31	65.29
Hard Surface	52.4572	6.4444	2.0379	47.8471	57.0672	41.77	60.70
Total	53.6500	7.1554	1.6000	50.3012	56.9988	40.31	65.29
Predicted Value Math							
Carpet	51.6590	7.8618	2.4861	46.0350	57.2830	38.35	63.59
Hard Surface	49.4410	6.0746	1.9210	45.0955	53.7865	39.11	55.76
Total	50.5500	6.9319	1.5500	47.3058	53.7942	38.35	63.59
Predicted Value Total Battery							
Carpet	52.6036	6.6829	2.1133	47.8229	57.3842	40.34	61.99
Hard Surface	50.7964	4.9495	1.5652	47.2558	54.3370	42.29	56.75
Total	51.7000	5.7982	1.2965	48.9864	54.4136	40.34	61.99

B. ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Predicted Value Reading						
Between Groups	28.458	1	28.458	.542	.471	
Within Groups	944.340	18	52.463			
Total	972.798	19				
Predicted Value Math						
Between Groups	24.597	1	24.597	.498	.489	
Within Groups	888.376	18	49.354			
Total	912.973	19				

Predicted Value Total Battery					
Between Groups	16.330	1	16.330	.472	.501
Within Groups	622.425	18	34.579		
Total	638.754	19			

The plots of the student achievement scores are shown in Figures 8 through 10. Table 9 reveals that the mean adjusted reading score (54.8428) in carpeted classrooms and hard surfaced classrooms (52.4572). While this is not a statistically significant difference ($p = .471$), it reveals that the average score in this study was 2.3856 points higher in the carpeted classrooms. Figure 10 demonstrates the adjusted math score (variable 40) in carpeted classrooms (51.6590) and hard floor surfaces (49.4410). Again, though not statistically significant, the average score is 2.2180 points higher in the carpeted classroom. Additionally, a difference, not statistically significant, of 1.8072 points is emphasized in Figure 11 with regard to the complete total battery (variable 41). The carpeted classroom adjusted score was 52.6036, while the hard floor surface adjusted score was 50.7964.

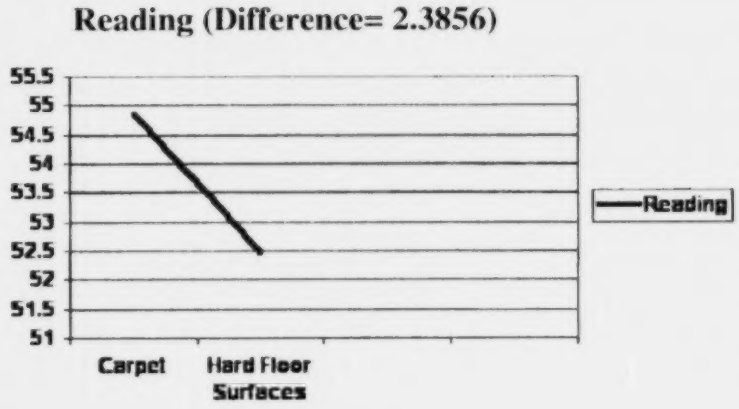

Figure 8 Adjusted Reading Test Scores

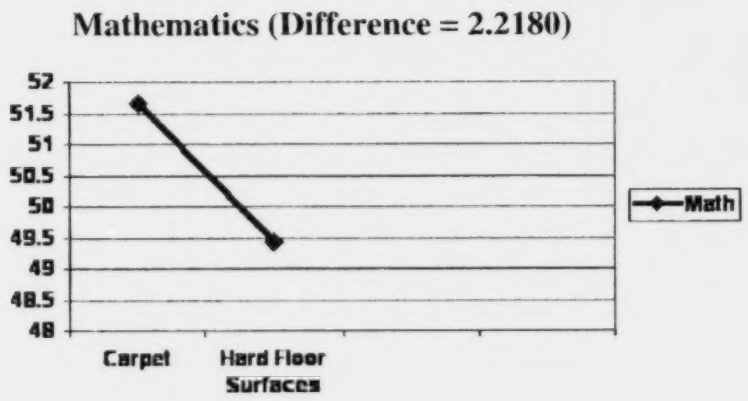

Figure 9 Adjusted Mathematics Test Scores

Complete Battery (Difference = 1.8072)

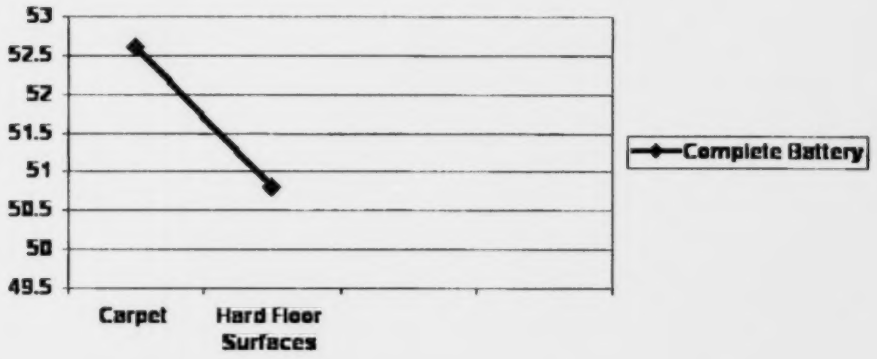

Figure 10 Test Scores on the Complete Battery

Summary, Conclusions, and Recommendations

This study examined the perceptions of elementary school principals regarding school design and the relationship between specific elements of design as a function of student performance. Additionally, the study focused on acoustics and the relationship between acoustics and floor coverings and student achievement.

Summary and Conclusions

Elementary school principals were surveyed in order to identify their perspectives regarding design elements and student performance. Over 95% indicated that school interior design is important for creating a good learning environment. Over 90% suggested that the schools' interior design strongly impacts teacher retention. Approximately 85% agreed that interior design is somewhat to very important in influencing student attendance. In comparison, Schapiro (2000) determined that approximately 99% of the national teachers surveyed found interior design very important to somewhat important for creating a good learning environment. Nearly 90% of the teachers perceived that interior design is at least somewhat important for teacher retention. The interior design is somewhat to very important to almost 70% of the teachers (Schapiro, 2000) (See Figure 11). From this comparison, it was concluded that the importance of the interior design of a school is a slightly higher priority for school principals than teachers.

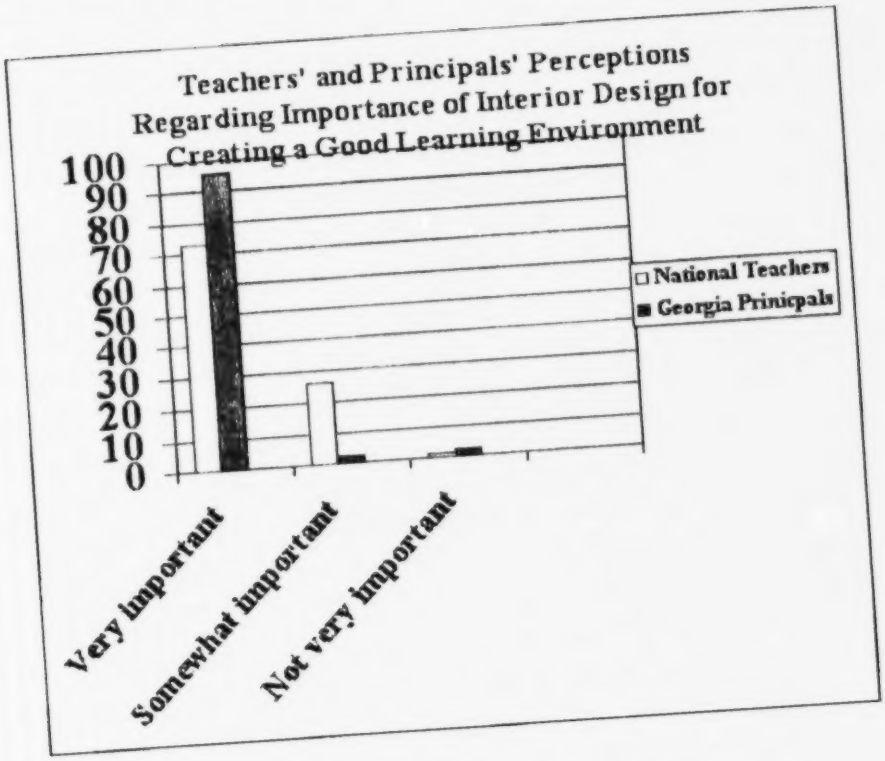

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Figure 11 Teacher and Principal Perceptions of Interior Design for Creating Good Learning Environment

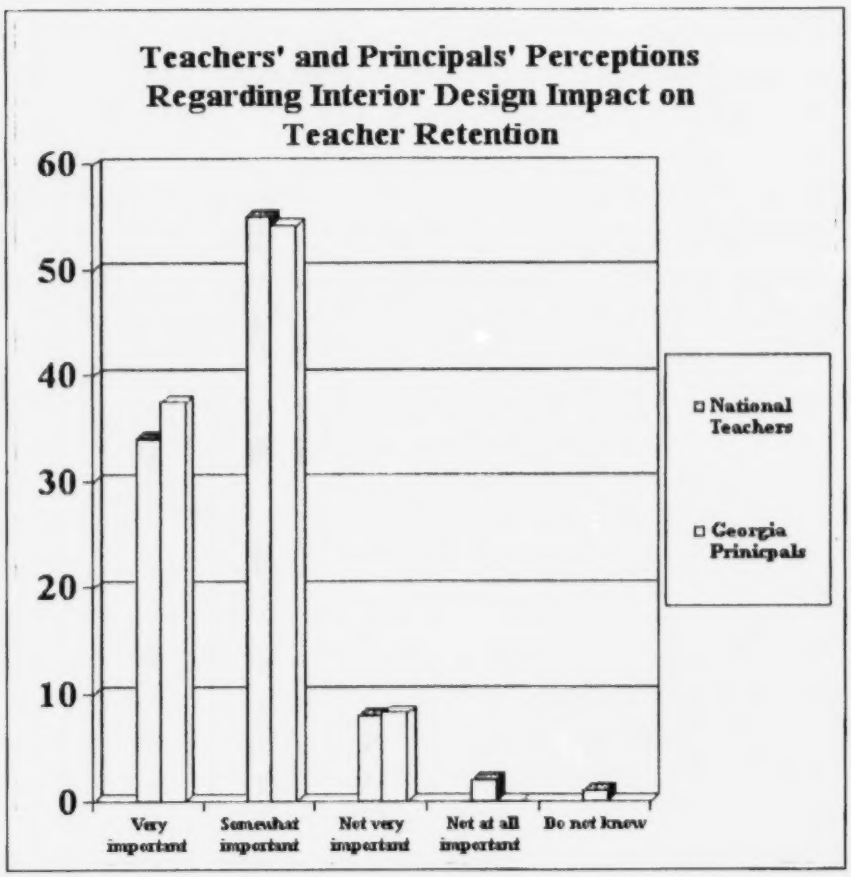

Figure 12 Teacher and Principal Perceptions of Interior Design on Teacher Retention

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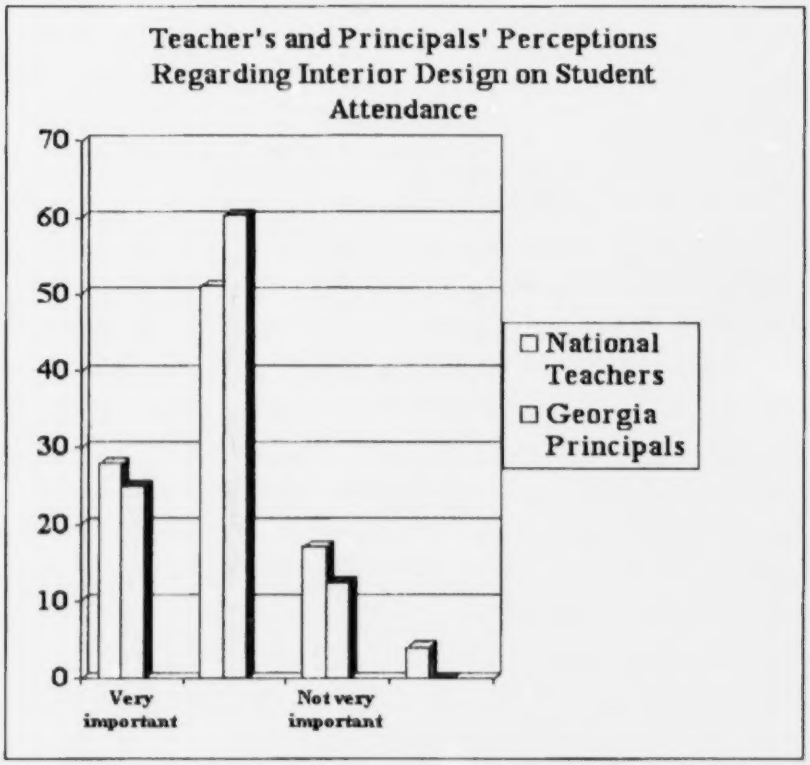

Figure 13 Teacher and Principal Perceptions of Interior Design on Student Attendance

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Ninety-four percent of principals indicated the classroom design has a somewhat strong to very strong impact upon student achievement. According to Schapiro (2000), 92% of teachers surveyed viewed classroom design as an influence on student achievement. Over 85% of principals regarded natural lighting as having a somewhat strong to very strong impact upon student achievement. Ninety-four percent of principals suggested that the ability to control the lighting has at least somewhat of an impact on student achievement. The flexibility of room arrangement is viewed to have somewhat of an impact to a strong impact on student achievement by approximately 90% of principals. Fifty percent of principals perceived that a carpeted classroom impacts student achievement. An overwhelming 98% of principals indicated the impact of a quiet environment to have at least somewhat strong impact on student achievement. In addition, 96% noted minimizing accidents has somewhat of an impact to strong impact on the student achievement. Over 80% indicated that a classroom that is easy to clean impacts student achievement. Furthermore, 100% of those surveyed suggested that comfortable seating impacts student achievement.

Only 63% surveyed noted that attractive floor colors impacts student achievement. However, at least 45% felt texture of the floor has an impact on student achievement. Floor patterns are thought to impact student achievement, according to 40% of the responders.

Eighty to ninety percent of those surveyed considered their floor coverings to be well to very well cleaned and maintained. Ninety-four percent agreed carpet absorbs noise. Over 66% of principals surveyed suggested carpet helps to prevent falls, and approximately 88% agreed carpet gives flexibility (See Figure 14). However, 52% disagree that carpet is easy to maintain. Almost 90% agreed carpet is more comfortable to stand on while teaching.

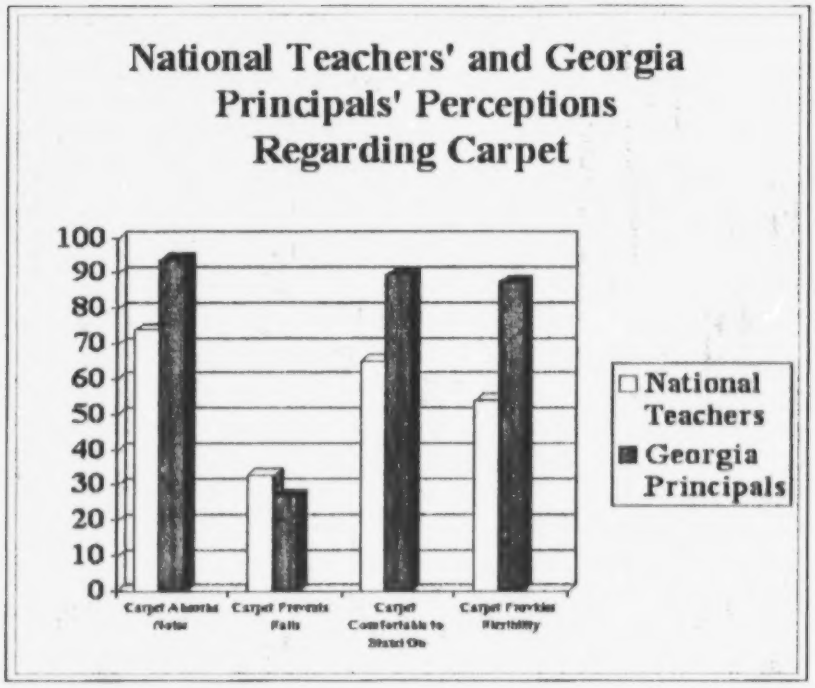

Figure 14 Teacher and Principal Perceptions of Carpet

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Seventy-nine percent of principals reported the overall condition of their school to be at least in good status. Additionally, 81% indicated the overall condition of the classroom to be in good or better condition. The majority of principals noted their classroom designs to be less than adequate as 62% of the principals surveyed rated the overall design of the classrooms as poor or fair. Only 33.3% gave the design a rating of good or very good. Light or neutral carpet is the most prevalent floor covering, approximately 50% of the responders. Thirty percent preferred carpet; nearly 10% prefer tile, less than 10% preferred vinyl or hardwood, and 50% preferred a combination of carpet and other surfaces. More than half, 56%, rated the acoustics as good to superior. The remaining 41.7% give poor to fair grades to the acoustics.

Principals and teachers recognize the importance of design elements upon student outcomes. Throughout the study, principals and teachers are cited to have some similar perspectives relative to the aspects of facility design, but there were some discrepancies regarding the importance of acoustics and learning. Principals placed more emphasis on the interior design than teachers, although they did not attach as much importance to the physical environment's ability to influence student attendance as teachers. Additionally, teachers and principals prefer carpet or some combination of carpet and hard surface flooring in elementary classrooms. The correlations between reverberation time and student achievement were negative for reading, mathematics, and the complete test battery. The conclusion from this set of statistics is that in classrooms with lower reverberation times, overall student achievement is higher. This supports the finding of Glass (1985) that unwanted noise reduces human energy and efficiency.

Research question 3 dealt with floor covering and its relationship to the acoustics of the classroom. This study found a significant difference in reverberation times between carpeted classrooms and hard floor surfaced classrooms. Noise levels (reverberation times) in carpeted classrooms were significantly lower than in non-carpeted classrooms. These findings are supported by the Acoustical Society of America (2000), since carpet is cited as an absorption material to reduce reverberation time in classrooms. The conclusion from this finding is that classrooms with hard surfaces and no acoustical treatment (no carpet) are less desirable because of noise problems.

The dimensions of the classrooms appeared not to be factors, since most classrooms were square in shape. There was some variance in height as some ceilings were as low as 7 feet and others as high as 14 feet. The width in the portable units was differed from the regular classroom setting within the school building. These usually measure between 12 and 14 feet wide. Classrooms within the building measured between 23 feet and 30 feet wide. The length variance was only slight with regard to any of those classrooms measured for the purposes of this study.

To complete the analysis of data regarding the fourth research question, a comparison of student achievement according to floor type (carpet or hard floor surfaces) was made for reading, mathematics, and the complete test battery. Across all academic areas researched, students in classrooms having carpet scored higher than students in rooms having hard surfaced floor coverings. Although there was no statistically significant difference between the two surface classifications regarding student achievement (alpha = .05), the practical significance is highly important for student learning. For example, students in carpeted classrooms scored an average of 2.3856 achievement points higher in the area of reading as compared to students in non-carpeted

classrooms. Students in carpeted classrooms scored an average of 2.2180 points higher on standardized mathematics tests and an average of 1.9072 points higher on the complete battery area as compared to students in classrooms with hard surfaces. Practical significance may be considered in cases where consistent findings having social and academic importance are discovered. The findings noted above led to the conclusion that on the average students in carpeted classrooms score higher on standardized tests, hence the notion of "good acoustics" has merit when student outcomes are considered.

Although there was no causal relationship established in this study, a trend in favor of carpeted classrooms and "good acoustics" emerged. Such data acknowledge the importance of the advice of the Acoustical Society of America (2000) that acoustical problems in the classroom setting can be avoided with forethought and planning in the design phase of the facility. Furthermore, the best remedy for such acoustical problems is soft, sound absorbing surfaces. These findings support the Carpet and Rug Institute's (2001) contentions suggesting that "Carpet is an investment in our schools, our children, and the learning environment" (p. 2).

Recommendations

In conducting a follow-up study the survey instrument should be more specific to help clarify the "best places" for site visits. The idea of *combination* should be more clearly defined to note whether the combination is within the classroom and with what specific floor covering materials. It would be advantageous to have principals identify classrooms of like dimensions and shape, same grade level, and different floor coverings. Only 48 of the 100 surveys were returned, therefore shortening the questionnaire might increase returns. However, some non-responders may not have given much thought to the influence of the physical environment on student learning.

Collecting the data during the school year rather than in the summer would ensure that the classrooms visited would be in their natural state with regard to furniture arrangements. Addressing and more specifically quantifying absorbent materials is necessary in follow-up studies. Determining a scientific measure of the quality of floor covering would create a more thorough study. Focusing the research to include the students' perspective could also produce a more valuable study, since the client's perspective would be compared to perspectives of principals and teachers.

Another recommendation is to measure different octaves and frequency ranges. This could be accomplished by using a white noise generator with omni directional speakers or a speech intelligibility meter rather than using a starter pistol or popping a paper bag. Such measuring devices would help to reduce variations in reverberation times, a problem that was discovered in this study.

This study was focused in Georgia and was well represented with random site visits throughout the state. However, as Schapiro's (2000) study was a national one citing differences of floor covering and presence of varying attitudes regarding floor covering, it is recommended the study be expanded outside the state of Georgia. This expansion should be approached with caution, since data reporting among several states may become an unwieldy problem.

Given the results of this study, including the response rate of less than 50%, it is recommended that more training be given to teachers and principals regarding the importance of the physical environment to student outcomes. Finally, this study sets the stage for implementing educational policy that includes strict acoustical regulations

within learning environments. Because the average of 35 decibels for background noise and between .4 and .6 seconds of reverberation time are the standards for hearing, and the majority of schools' classrooms in this study did not meet these standards, it is important that state and local policy be implemented to ensure "good acoustics" in schools of Georgia.

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